The Microdilatometer

disc is provided. When the D operates with rollers 0.3-5.0 mm in diameter, its magnification is computed by the formula: $\Delta h = 2H/d\,\Delta\ell$, where $\Delta\ell$ is the displacement of the upper end of the quartz rod, d is the diameter of the roller, H is the length of the light beam, and Δh is the displacement of the beam on the photosensitive paper, which corresponds to the displacement $\Delta\ell$. It is noted that, despite the great sensitivity of the instrument, even tapping the head of the dilatometer with a finger fails to produce a permanent displacement of the beam upon the scale.

Yu. L.

1. Dilatometers-Design 2. Dilatometers-Operation

Card 2/2

IVANOV, O. S.

137-58-1-1980

Translation from: Referativnyy zhurnal, Metallurgiya, 1958, Nr 1, p 265 (USSR)

AUTHOR: Ivanov, O. S.

TITLE: A Method for Calculating Experimental Dilatometer Curves (Metodika rascheta eksperimental'nykh dilatometricheskikh krivykh)

PERIODICAL: Tr. In-ta metallurgii AN SSSR, 1957, Nr 1, pp 185-192

ABSTRACT: A proposal is advanced for a new method of calculation of experimental curves obtained by a Chevenard optical differential dilatometer. The method makes it possible to perform more advanced quantitative analysis of thermal expansion and dilatometric effects due to phase transformations. An accessory to be used with a Chevenard dilatometer, which renders possible tests in vacuum at temperatures of up to 900-1000°C with specimens that oxidize or even burn at 300° in air, is described. A description is presented of a method of calibrating the dilatometer. It is shown that certain of the initial assumptions accepted in the usual methods of calculation of dilatometer curves do not hold in all cases, and that a number of parameters depend upon the individual features of a given

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137-58-1-1980

A Method for Calculating Experimental Dilatometer Curves

dilatometer. A method of employing the expansion constant of an Ni standard for temperature calibration of dilatometer curves is suggested. Experimental errors for various types of dilatometer investigations are examined.

L.M.

1. Dilatometer--Curves--Mathematical analysis

Card 2/2

SOV/137-57-11-22598

Translation from: Referativnyy zhurnal, Metallurgiya, 1957, Nr 11, p 282 (USSR)

AUTHOR: Ivanov, O. S.

TITLE: Measurement of Electrical Resistance of Metals and Alloys During Heating to 1100°C (Izmereniye elektrosoprotivleniya metallov i splavov pri nagreve do 1100°)

PERIODICAL: Tr. In-ta metallurg. AN SSSR, 1957, Nr 1, 193-195

ABSTRACT: An apparatus for the investigation of the variations of the electrical resistance (E) in relation to the temperature is described. The specimen (S) was placed into a sealed quartz tube evacuated to 10^{-1} and 10^{-2} mm Hg. The tube was inserted into a resistance furnace which can be heated to 1200°C. Four Pt wires 0.55 mm in diam and a thermocouple were brought up to the S through a special stopper and electrically spark-welded to the S. Two wires welded to the ends of the S served for conveying a direct current with a voltage (V) of 100 v from an Se rectifier which was supplied with alternating current through a V stabilizer. Two wires welded closer to the middle of the S recorded the V drop over a specified length of S. The E on the given section of S was determined by the

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Measurement of Electrical Resistance of Metals (cont.)

following formula: $R_{sp} = R_{st} \alpha_{sp} / \alpha_{st}$, where R_{st} is the magnitude of the standard resistance, α_{sp} and α_{st} are the values for the V drop on the S and on the standard resistance, respectively, measured on the scale of a needle galvanometer with a constant value for the coefficient of proportionality between the applied V and the magnitude of the deviation of the galvanometer needle over the entire scale of the instrument. The measurements of α_{sp} and α_{st} were carried out directly one after the other with a double-pole switch. The apparatus is equipped with a six-point self-recording potentiometer for the automatic recording of the values for α_{sp}, α_{st}, and temperature. The V drop on the standard and the current intensity varied little during the experiment, which is explained by the presence of a 100 ohm buffer resistance in the circuit of the S. Under these conditions the curve of the V drop on the S, except for a scale factor, is also the curve of the E, which under conditions of a smooth rise in temperature during the heating of the S can be used without any recalculations for the determination of the temperatures of phase transitions in the alloys. To effect a steady increase in the temperature of the S, an automatic potential regulator, whose output V during the experiment was steadily increased from zero to the maximum

Measurement of Electrical Resistance of Metals (Cont.)

(150 v), was connected to the furnace. The specific E - temperature curves for Armco-Fe and the constants according to visual readings and as recorded automatically are adduced.

L. G.

IVANOV, O.S.

137-1957-12-23222

Translation from: Referativnyy zhurnal, Metallurgiya, 1957, Nr 12, p 52 (USSR)

AUTHORS: Ivanov, O. S., Tarasov, A. I.

TITLE: A Device for the Maintenance of Required Temperatures in Programed Heating and Cooling Operations (Prisposobleniye priborov dlya podderzhaniya zadannykh temperatur k programmnomu nagrevu i okhlazhdeniyu)

PERIODICAL: Tr. In-ta metallurgii AN SSSR, 1957, Nr 1, pp 196-198

ABSTRACT: A description of a device consisting of 0.1 mm Pt wire wound around a pulley and capable of maintaining any desired small rate of heating or cooling in the furnace by means of a contact galvanometer or potentiometer; the device slides downward with a constant velocity along a stationary contact under the influence of a load and a timing mechanism; a second contact is attached to the other end of the wire. The Pt wire serves as a conductor for a current, the magnitude of which is controlled by a resistor. The contact galvanometer maintains a constant value of the sum of the emf E_t of the thermocouple and of the voltage drop V_d in the Pt wire, which increases with the descent of the wire; thus

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137-1957-12-23222

A Device for the Maintenance of Required Temperatures (cont.)

the contact galvanometer regulates the furnace temperature in such a manner as to lower the value of E_t by an amount equal to the increase of V_d; in application this is virtually equivalent to a linear decrease of temperature in the 1100 - 500° range.

G. G.

1. Temperature-Control 2. Galvonometers-Applications

Card 2/2

IVANOV, O. (and V. Grigorovich)

"STRUCTURE AND PROPERTIES OF ZIRCONIUM ALLOYS".

By O. Ivanov and V. Grigorovich.

Report presented at 2nd UN Atoms-for-Peace Conference, Geneva, 9-13 Sept. 1958.

IVANOV, O. and BADAYEVA, T.

"Phase Diagrams of Certain Uranium and Thorium Systems."

paper to be presented at 2nd UN Intl., Conf. on the peaceful uses of Atomic Energy, Geneva, 1 - 13 Sept 58.

IVANOV, O.S.

Transformations in Fe-FeAl and Fe-CoAl alloys. Trudy Inst.met. no.3: 195-202 '58. (MIRA 12:3)
(Iron-aluminum alloys--Testing) (Phase rule and equilibrium) (Dilatometry)

78-3-3-5/47

AUTHOR: Ivanov, O. S.

TITLE: Successes and Perspectives in the Investigation of the Phase Diagrams of Metallic Systems (Dostizheniya i perspektivy v oblasti izucheniya diagramm sostoyaniya metallicheskikh sistem)

PERIODICAL: Zhurnal Neorganicheskoy Khimii, 1958, Vol.3, Nr 3, pp.585-600 (USSR)

ABSTRACT: Above all the works on the investigation and construction of the phase diagrams of polycomponent systems were treated. In the investigation of the phase diagrams the conditions for the occurrence of solutions, solid and liquid ones, were especially taken into account. The occurrence of liquid solutions is in some cases of great importance. Thus e.g. molten magnesium is used as extraction solvent for uranium. The occurrence of solid solutions is of still greater importance. The modifications of the chemical, mechanical and physico-chemical properties of the alloys are connected with the formation of these solid solutions. The author investigated phase diagrams with metals which are widely

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Successes and Perspectives in the Investigation of the Phase Diagrams of Metallic Systems

used in the new technology of semi- and super-conductors as well as in atomic engineering, e.g. in the systems Ti-Zr, Zr-Nb, Zr-Sn, U-Zr, U-Nb and U-Mo. In the construction of the phase diagrams the thermodynamic calculations, the interaction among the atoms of the components, the parametric equilibrium, the concentration of the components, the temperature and the pressure were taken into account. The construction of the phase diagrams was especially facilitated by the thermodynamic calculations and thereby the results obtained in experiments were corrected. The stability of the crystal-lattice in the formation of solid solutions is subject to the same rules governing the interrelationship of the elements in the periodic system. Of great importance is the elaboration and construction of the phase diagrams of chromium, niobium, tantalum and tungsten. Niobium is an extremely valuable metal for aviation and atomic reactors. The phase diagrams of zirconium-thorium and uranium-plutonium were investigated with a high interest for atomic energy. With uranium altogether 57 binary systems and 6 ternary systems were produced. The methods for the production of the alloys were also perfected, especially for

78-3-3-5/47

Successes and Perspectives in the Investigation of the Phase Diagrams of Metallic Systems

the production of alloys in the arc furnace, in an inert atmosphere and a vacuum. A new differential thermodynamic method was worked out for the determination of the phase transformation and especially for the determination of the points of the liquidus. Due to the development of technology the phase diagrams of binary, ternary or polycomponent systems with titanium, chromium, niobium, molybdenum, tantalum, tungsten, germanium, silicon, zirconium, beryllium, uranium and plutonium shall be investigated. There are 14 figures and 19 referenoes, 10 of which are Soviet.

ASSOCIATION: Institut metallurgii im. A. A. Baykova Akademii nauk SSSR (Metallurgical Institute imeni A. A. Baykov, AS USSR)

SUBMITTED: June 25, 1957

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IVANOV, O.S.

Discussion. Zhur.neorg.khim. 3 no.4:948 Ap '58. (MIRA 11:4)

1.Institut metallurgii im. A.A. Baykova AN SSSR.
(Phase rule and equilibria) (Chemical bonds)

AUTHOR: Ivanov, O.S. 2o-119-2-22/6o

TITLE: The Influence of Admixtures on the Temperature of Polymorphous Transformations of Metals (Vliyaniye legirovaniya na temperatury polimorfnykh prevrashcheniy metallov)

PERIODICAL: Doklady Akademii Nauk SSSR, 1958, Vol 119, Nr 2, pp 271 - 273 (USSR)

ABSTRACT: In the periodic system a regular distribution of the characteristic crystal lattices is observed. Thus the transition metals of the third group have, for instance, a densely packed hexagonal lattice. The metals of the 4th,5th and 6th group have a cubic volume-centered lattice. The elements of the 7th and 8th group have first a densely packed hexagonal lattice (Tc,Ru,Re,Os) and then a cubic face-centered lattice(Ni,Cu, Rh,Pd,Ag,Ir,Pt,Au).In the metals bordering these periods the lattices of the two bordering sections are observed which can be noticed by the existence of various modifications of these metals. To these belong, for instance,Ti,Zr,Hf,Th,Mn,Fe and also U,Np,Pu. The presence of one or the other lattice can be brought into connection with the fact in which group

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The Influence of Admixtures on the Temperature of Polymorphous Transformations of Metals

the given metal is located and how many electrons are present in its incompletely filled shells. A certain influence of this factor can be noticed in the case of lanthanides and of actinides in which the crystal lattices on the admixture of 4f- and 5f-electrons change only little. On the other hand the metals of the group 1b(Cu,Ag,and Au) occur as metals with a great number of electrons in the incompletely filled electron shell. The formation of solutions causes a certain displacement within the periodic system from the place of the solvent to that of the dissolved substances. When the solvent is a polymorphous metal the one or the other modification stabilizes, depending,on to which section the above mentioned displacement is leading. Based on these considerations the widening of the temperature range of the α-solid solution can,for instance, be explained by the narrowing of the range of the γ-solid solution in the dissolution of Ti, V,Cr,Nb,Mo,Ta,W,U,Ce,Sn,Sb, Be,Al,Si,P, in iron. On the other hand the solution of

The Influence of Admixtures on the Temperature of Polymorphous Transformations of Metals

Co,Ni,Cu,Rh,Ru,Pd,Os,Ir,Pt,Au in Fe widens the temperature interval of γ-solid solutions by narrowing the range of α-solid solution. In the formation of solid displacement solutions of Ti and Zr with such elements which have more than 4 electrons in the incompletely filled shells a cubic volume-centered lattice must become stabilized. La,Ce,C and Th form it center in the densely packed face-centered lattice. The same rule applies also for the system with U. Thus a general rule on the influence of alloying elements on the polymorphous transformations of many important metals was observed. There is 1 figure.

ASSOCIATION: Institut metallurgii im. A. A. Baykova Akademii nauk SSSR (Institute for Metallurgy imeni A. A. Baykov, AS USSR)

2o-119-2-22/6o

The Influence of Admixtures on the Temperature of Polymorphous Transformations of Metals

PRESENTED: June 21, 1957, by I. P. Bardin, Member, Academy of Sciences, USSR

SUBMITTED: June 21, 1957

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20-119-6-24/56

AUTHOR: Ivanov, O. S.

TITLE: Some Rules Governing Binary Metallic Systems (Nekotoryye zakonomernosti v dvoynykh metallicheskikh sistemakh)

PERIODICAL: Doklady Akademii nauk SSSR, 1958, Vol. 119, Nr 6, pp. 1142 - 1144 (USSR)

ABSTRACT: As in the expression for the thermodynamic potential all the terms except the entropy of the shift are finally connected with the interaction of the atoms, the phase diagram which corresponds to the minimum of the thermodynamic potential is an image of the chemical interaction of the components. Their shape depends on the structure of the external electron shell of the atoms of the components (i.e. on their dimensions, energy levels, and their filling with electrons). The resemblance of the interatomic distances (diameter of the atoms in the crystal lattice) and of the electron formulae makes the formation of solid solutions possible. This showed up in the long ago formulated demands: Simultaneous presence of a favorable volume factor and of a favorable electrochemical factor, resemblance of the wave functions of the valence electrons and of the number of the so called free electrons. However, the predominating character of the chemical factor with respect to the dimension factor must be mentioned. Thus copper is limitedly soluble in γ-iron, but palladium unlimitedly, although copper with regard to the dimension of its atoms is nearer to iron than palladium. Silver forms with iron solutions neither in liquid nor in solid state, but gold does. This seems to be dependent on the great chemical resemblance between the electron shells $Fe3d^64s^2$ and $Au5d^{10}6s^1$. The system Mn-Cu has an unlimited solubility. In the system Cr-Cu a domain exists in which there is no mixture possible in liquid state. Further details are given. The lattice number and the lattice strength of binary systems clearly depend on the external unfilled state of the electron shells of the components and on the position of the components in the periodic system. Further details are given. The investigation of the collected experimental data on the phase diagrams of binary systems speaks for the possibility of setting up general rules governing the dependence of the character of the diagrams of the chemical nature of the components. These rules will contribute to the understanding of the complicated picture

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Ivanov, O.S.

21(4) PHASE I BOOK EXPLOITATION SOV/2714

International Conference on the Peaceful Uses of Atomic Energy. 2nd, Geneva, 1958

Doklady sovetskikh uchenykh; yadernoye goryucheye i reaktornyye metally. (Reports of Soviet Scientists; Nuclear Fuel and Reactor Metals) Moscow, Atomizdat, 1959. 670 p. (Series: Its: Trudy, vol. 5. 8,000 copies printed.

Ed. (Title page): A.A. Bochvar, Academician, A.P. Vinogradov, Academician, V.S. Yemel'yanov, Corresponding Member, USSR Academy of Sciences, and A.P. Zefirov, Doctor of Technical Sciences; Ed. (Inside book): V.V. Pereverzev and G.M. Pchalintseva; Tech. Ed.: E.I. Mazel'.

PURPOSE: This volume is intended for scientists, engineers, physicians, and biologists working in the production and peaceful application of atomic energy; for professors and students of schools of higher technical education where the subject is taught; and for people interested in atomic science and technology.

COVERAGE: This is volume 5 of a 6-volume set of reports on atomic energy, presented by Soviet scientists at the Second International Conference on the Peaceful Uses of Atomic Energy, held in Geneva from September 1 to 13, 1958. Volume 5 consists of two parts. The first part, edited by A.I. Zubov, is devoted to geology, prospecting, concentration and processing of nuclear source material. The second part, edited by O.L. Zverev, includes 27 reports on metallurgy, metallography, processing technology of nuclear fuels and reactor metals, and neutron irradiation effects on metals. The titles of the individual papers in most cases correspond word for word with those in the official English language edition on the Conference proceedings. See SOV/2081 for the titles of the other volumes of the set.

Card 6/11

18 (6)
AUTHORS: Ivanov, O. S., Semenchenkov, A. T. SOV/78-4-6-34/44

TITLE: The Zirconium Angle of the Phase Diagram of the System Zr-Sn-Mo (Tsirkoniyevyy ugol diagrammy sostoyaniya sistemy Zr-Sn-Mo)

PERIODICAL: Zhurnal neorganicheskoy khimii, 1959, Vol 4, Nr 6, pp 1420 -1427 (USSR)

ABSTRACT: The structure of the three-component alloys of zirconium with tin and molybdenum up to 4 gram - atomic percentage was investigated in dependence on temperature. Zirconium free from hafnium, granulated lead p.a. and molybdenum with little impurities of ReO - 0.03%, Ni -0.004%, CaO + MgO - traces and SiO_2 - 0.002% were used for the production of the alloys. The phase condition of the alloys at 900°, 800°, 700°, and 525° is given in figure 1. The metallographic and X-ray structure analyses showed that the structure of the alloys is characterized by the isothermal sections in the zirconium angle of the phase diagram. The results of the microstructural investigations of the hardened alloys (900°) are given in figure 2 (a - s). The zirconium alloys with molybdenum and lead up to 4 gram - atomic percentage from

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solid α- and β-solutions and intermetallic phases $ZrMo_2$ and Zr_4Sn exist in dependence on temperature. The change of the parameter of the α- and β-phase in the alloys with 10 gram - atomic percentage Sn+Mo which were hardened at 900° is given in figure 3. The microstructure- and X-ray analyses of the alloys with 10 gram - atomic percentage Sn+Mo show an increase of the $ZrMo_2$ formation. The radiographs of the alloys which were hardened at 700° are given in figure 6. The radiograph of the alloy of zirconium with 3 gram - atomic percentage Mo, hardened at 675°, 685°, and 700° is given in figure 8. The microstructure of these alloys is given in figure 7 (a - w). The eutectoid horizontal line which corresponds to the transformation $\beta \rightleftarrows \alpha + ZrMo_2$ lies in the system zirconium-molybdenum at 680° and is therefore by 100° lower than that given in publications (Ref 7). In all investigated alloys with 4 gram - atomic percentage Sn+Mo only the α-phase is formed at 525°. The projection on the concentration surface of the polythermal diagram

The Zirconium Angle of the Phase Diagram of the System Zr-Sn-Mo SOV/78-4-6-34/44

is given in figure 9. The scheme of the nonvariant and monovariant reactions in the zirconium angle of the system zirconium-lead-molybdenum is given in figure 10. There are 10 figures and 7 references, 2 of which are Soviet.

SUBMITTED: March 1, 1958

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SOV/78-4-7-27/44

5(2), 18(6), 18(7)

AUTHORS: Ivanov, O. S., Semenchenkov, A. T.

TITLE: The Conversion of the Ternary Alloys of the Zirconium-corner of the System Zr - Sn - Mo in Hardening and Tempering (Prevrashcheniye troynykh splavov tsirkoniyevogo ugla sistemy Zr - Sn - Mo pri zakalke i otpuske)

PERIODICAL: Zhurnal neorganicheskoy khimii, 1959, Vol 4, Nr 7, pp 1625-1629 (USSR)

ABSTRACT: In an earlier paper (Ref 1) the zirconium corner of the system mentioned in the title was described when in equilibrium. There now follows the description of the structure of the same alloys in the case of an equilibrium disturbed by hardening or tempering. The investigation concerned zirconium alloys with up to 4 at% Sn+Mo. The alloys used are mentioned in the diagram (Fig 1). The investigation was carried out by means of X-ray- and microstructural analyses (Fig 2). The following results were obtained: 1) The β-phase existing in the ternary alloy Zr-Mo-Sn at high temperatures is converted by hardening either into the α'-phase with the lattice of α-Zr, or into the ω-phase with a hexagonal lattice of its own, according to the

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The Conversion of the Ternary Alloys of the Zirconium-corner of the System Zr - Sn - Mo in Hardening and Tempering

low or high Mo content. In this respect there is an analogy to many titanium alloys. 2) The greatest amount of hardness is attained in the conversion of the β-phase into the ω-phase. The molybdenum content in this case is of greater influence than the tin content. 3) The α'-phase formed by hardening, an oversaturated solution of Mo and Sn in α-Zr, decays by heating to 250-450°. The decay develops according to the scheme of heterogeneous aging. The greatest hardness ($350\ kg/mm^2$) is attained by tempering at 400°. Tempering at 500° reduced hardness to $250\ kg/mm^2$ as a result of the removal of distortions of the crystal lattice and coagulation of the separated phases. Alloys which are in the state β+ω-phase after hardening increase their hardness from 330 to 450 kg/mm^2 if tempering temperature is increased from 150 to 300°, although no structural changes could be detected by means of an X-ray examination. At 500° the β+ω-structure decays into a solid α-solution and probably into $ZrMo_2$. Tempering at

450-500° causes a considerable reduction of hardness. In figures 4-7 diagrams of hardness variations at various temperatures are shown. There are 7 figures and 3 references, 2 of which are Soviet.

SUBMITTED: March 1, 1958

S/509/60/000/004/016/024
E111/E152

AUTHOR: Ivanov, O.S.

TITLE: Methods for Calculating Phase Diagrams

PERIODICAL: Akademiya nauk SSSR. Institut metallurgii. Trudy, No.4, 1960. Metallurgiya, metallovedeni e, fiziko-khimicheskiye metody issledovaniya, pp.1 9-199

TEXT: This is a lecture given on 28th April 1956 at s seminar for scientists of the Institut metallurgii imeni A. . Baykova AN SSSR (Institute of Metallurgy imeni A.A. Baykov AS USSR). Assuming that the energy of interaction of atoms in a solution does not depend on its concentration, the author deduces equations for calculating phase diagrams some of wh ch agree with experimental results. He starts by deducing an equation for the free energy of a two-component solution wi h respect to one atom in terms of bonding energies, entropie: of component atoms and atom fraction of one component. He exa ines the type of curve obtained for solutions with positive and negative heat effects, with special reference to free-ener minima. The equation obtained is:

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Methods for Calculating Phase Diagrams

$$\frac{x_1^2 V' - x_2^2 V'' + kq_a T_a}{q_a - \ln \frac{1 - x_1}{1 - x_2}} =$$

$$= \frac{(1 - x_1)^2 V' - (1 - x_2)^2 V'' + kq_b T_b}{q_b - \ln \frac{x_1}{x_2}} = kT \qquad (6)$$

in which x_1, x_2 are the atom or mol fractions of component B in the coexisting phases stable at high and low temperatures respectively; T_a and T_b are fusion or polymorphic-change temperatures of the components; q_1 and q_2 are their entropies of fusion or polymorphic change related to one atom and divided by the Boltzmann constant; and V' and V'' depend on bonding energies (not defined precisely, probably heats of mixing).

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He uses this equation to derive expressions for phase-diagram curves for particular cases. The theoretical treatment cannot yet be used instead of experimental work; the two should be used simultaneously and efforts made to allow for the effect of atomic interaction on distribution in the lattice and hence the thermodynamic properties. C.Zener (Ref.6) has developed a method for calculating phase diagrams for medium-alloy steels; this is based on dilute-solution ideas and some experimental data. The author shows how the main equation is derived and shows some of Zener's comparisons of experimental and calculated alpha + gamma/gamma boundaries. The present author's general conclusion is that available calculation methods are valuable in checking experimental diagrams, especially for obtaining from them information on interaction of components in the separate phases. There are 4 figures and 6 references: 4 Soviet and 2 English.

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IVANOV, O.S.

Methods of establishing constitution diagrams. Trudy Inst. met. no.4:189-199 '60. (MIRA 14:5)
(Phase rule and equilibrium)

18.1152
21.2100
18.1283

33880
S/640/61/000/000/001/035
D258/D302

AUTHORS: Ivanov, O. S. and Bagrov, G. N.

TITLE: Investigating alloys in the system uranium-zirconium

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh system s uranom i toriyem. Moscow, Gosatomizdat, 1961, 5-19

TEXT: This work is considered to be the first step towards the study of the triple system uranium-zirconium-molybdenum. Zirconium was chosen as an alloying addition to uranium because of its low thermal neutron cross-section and also because of its ability to form solid solution with uranium. Specifically, 50 different alloys were prepared in crucibles lined with thorium oxide. The firing of the first series (in 1954) was performed in a high-frequency furnace and the resulting alloys were saturated with oxygen. The second (20 to 50 atom-% of Zr) and third (50 - 100 atom-% of Zr) series were prepared in an arc furnace, under pure argon. The chemical analyses made of some of the alloys were in agreement with

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Investigating alloys ...

the respective charge compositions and the latter were assumed to represent the 'true' composition of each alloy. The phase diagram of the system was based on the study of the microstructure, that of the crystalline lattices, and that of hardness vs. composition curves. For the latter investigation, the alloys were held for prolonged periods at 1000° - 500°C and were then quenched in water. A phase diagram shows a continuous series of solid solutions of γ-U in ß-Zr. At 735°C, the γ-solid solution decomposes in two phases of γ and γ_{Zr}; each phase is getting enriched in U or in Zr, respectively. This separation reaches a maximum at 35 at.-% of Zr. At 695° and 13 at.-% of Zr, the γ-phase is monotectically transformed into ß + γ_{Zr}; the monotectic horizontal line stretches from 2.5 to 51 at.-% of Zr. At 662°C, the ß-U-based solid solution decomposes, to yield α + γ_{Zr}. An intermediate δ_1-phase is formed at temperatures below 615 - 607°C. It was shown that within the range of 50 - 100 at.-% of Zr, this phase is formed from γ-solid solutions and according to the following reactions: (1) $\gamma_{Zr} \rightleftarrows \alpha + \delta_1$;

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Investigating alloys ...

(2) $\gamma_{Zr} + \alpha_{Zr} \rightleftarrows \delta_1$. The δ_1-phase is homogeneous at 500° - 600°C within the limits of 65 - 78 at.-% of Zr. The formation of the δ_1-phase was shown to proceed at a fast rate, at temperatures at which the γ_{Zr} solid solution was unstable; consequently, the fixation of γ_{Zr}-phase could be attained by abruptly chilling small specimens in water. The crystal lattice of the δ_1-phase was shown to be identical with both, the lattice of the phase formed by tempering alloys containing 90 - 91 at.-% of Zr and that of the ω-phase formed by the low-temperature tempering of titanium alloys and studied by Yu. A. Bagaryatskiy and co-workers (Ref. 6: Dokl. AN SSSR 105, 6 (1955)) and others. The electrical resistivity of the stabilized γ_{Zr}-solid solution is lower than that of the ω-phase (Ref. 6: Op. cit.) while that of the δ_1-phase is higher; the highest electrical resistivity found (max. 1.65×10^{-4} ohm-cm at 78 at.-% of Zr) was that of the δ_1-phase, formed by tempering from 500°C onwards.

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D258/D302

Investigating alloys ...

Also, the electrical resistivity of alloys containing 70 and 78 at.-% of Zr was increased after tempering them in a multi-stage process in the region of 200 - 300°C, thus transforming their previously 'fixed' δ_{Zr}-solid solutions into the δ_1-phase. This increase in resistivity is a measure of the increased order in δ_1 as compared with δ_{Zr}. There are 10 figures and 15 references: 8 Soviet-bloc and 7 non-Soviet-bloc. The 4 most recent references to the English-language publications read as follows: F. A. Bough and A. A. Bauer, Constitution of Uranium and Thorium Alloys. Report BMJ-1300, UC-25 Metallurgy and Ceramic (TJD-4500, 13th Ed., rev.), Bat. Mem. Inst., Columbus, Ohio, 1958; P. D. Frost, W. M. Parris and others, Trans. Amer. Soc. Metals, 46, 231 (1956); J. M. Silcock, M. H. Davies and H. K. Hardy, Nature, 175, 731 (1955); A. G. Knapton, J. Inst. Metals, 83 (August 1955).

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33881

S/640/61/000/000/002/035
D258/D302

21.2100

AUTHORS: Ivanov, O. S. and Terekhov, C. I.

TITLE: The equilibrium diagram and structure of alloys in the system uranium-niobium

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 20-34

TEXT: The system uranium-niobium was studied in view of its potential use as a high-melting nuclear fuel. Niobium was found to be a promising component because of its low thermal neutron cross-section, its crystalline structure, isomorphous with that of γ-U, and its high melting point. The present work is thought to clarify the nature of the equilibrium between α, β and γ phases in the uranium corner of the diagram. Specifically, 65 alloys were prepared by melting together 99.69% pure U and 98.2% pure Nb powder in either an induction or an arc furnace, under reduced pressures of

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The equilibrium diagram ...

purified argon or at 10^{-2} mmHg. The specimens were annealed for 48 - 72 hours at 1000 - 1250°C, depending on their Nb contents. They were investigated by chilling them at different temperatures and analyzing afterwards by X-rays, microstructural, thermal, and dilatometric methods. A resulting equilibrium diagram is given. The hardness curve of samples quenched from 1000°C shows a maximum of 400 kg/mm^2 at 5 at.-% of Nb, corresponding to the martensitic transformation, $\gamma \rightarrow \alpha'$; a minimum at 17.5 at.-% of Nb is followed by a smooth maximum, the latter indicating a continuous series of solid solutions. The X-ray pattern of a 17 at.-% containing alloy (quenched from 900°C) shows a body-centered, tetragonal lattice, with the calculated dimensions of a = 3.531 kX and c = 3.360 kX. These parameters decrease with increasing Nb contents of the alloy. Prolonged annealing at 840°C, of samples containing 30 - 65 at.-% of Nb caused the solid solution to be partially decomposed in two phases: γ and γ_{Nb}. This two-phase region reaches its maximum at 990°C and ~50 at.-% of Nb, as ascertained by x-ray data and micro-

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The equilibrium diagram ...

graphy of samples quenched from 910°, 850°, 1000° and 1070°C. The equilibrium, γ-solid solution:ß-solid solution in the uranium-rich section was established with the aid of micrography. Dilatometric and thermal analyses failed to establish (1) the solubility of Nb in α-U and (2) nature of the invariant equilibrium between the α, ß and γ phases. The latter was accomplished by first homogenizing alloys containing 0.01 to 11 at.-% of Nb, dividing each sample in 3 lots heating each lot for 600 hrs at 630°, 637° and 645°C, respectively, and finally quenching the samples in water. The resulting hardness curve does not indicate sharply defined boundaries. X-ray patterns reveal gradually developing γ_{Nb}-lines, beginning from 2 at.-% of Nb. The parameters of the α-phase are practically the same as those of pure U; those of γ_{Nb} (a = 3,340 kX) correspond to a Nb-content of 75 at.-%. The solubility problem was solved by testing the hardness of alloys, quenched from 630°C and held afterwards at 500°C for 2 mins, and 24 hrs. The resulting ageing curves show that Nb is practically insoluble in α-U. The existence of the (α + ß) region and the eutectoid reaction ß $\rightleftarrows \alpha + \gamma_{Nb}$ (at 670°C)

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The equilibrium diagram ...

were established by indirect methods. The differences between the equilibrium diagrams of the systems U-Mo and U-Nb are explained in terms of their respective thermodynamic potential curves. There are 10 figures, 2 tables and 1 Soviet-bloc reference.

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21.2100

AUTHORS: Ivanov, O. S. and Virgil'yev, Yu. S.

TITLE: Decomposition of the niobium-uranium γ-solid solution

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh sistem s uranom i toriyem. Moscow, 1961, 35-47

TEXT: This paper describes the investigation of the decomposition process of a γ-solid solution, whose existence has been shown by the author and G. J. Terekhov (Ref. 1: This publication, p. 20) within the composition range of 20 - 70 at.-% of Nb. Specifically, alloys containing 20, 30, 40, 50, 60 and 70 at.% of Nb were quenched (from 1000°C) and then held, for periods of 50 hrs each, at a series of successive increasing temperatures. At the end of each heating period, the sample was subjected to hardness tests and x-ray analyses. The results are as follows (samples are referred to by numbers 1 to 5 in the order of their increasing Nb contents): The hardness (in kg/mm^2) of sample 1 increases greatly, from 180

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Decomposition of the ...

at 0°C to a maximum of 55 at 450°C and decreases sharply, to 400 (at 600°C); Sample 2 exhibits similar characteristics and a maximum (at 460°C), with the upward slope beginning only at 210°C; the slope of sample 3 is still less pronounced and its maximum lies at 520°C; sample 4 exhibits a slight rise, from 350 kg/mm^2 to about 400 (at 550°C), without any maximum; and the last two samples do not change their hardness at all. X-ray analysis of sample 2 shows that its parameter a_γ remains constant up to 280°C and slopes then in a straight line downwards, attaining 3.351 kX at 590°C (near to 3,34 kX, for $a_{\gamma_{Nb}}$); a_γ for samples 3 and 4 remains unchanged, at 3.41 kX and 3,38 kX, respectively. The a_γ lines of sample 3 disappear at 500°C and are replaced by lines, characteristic of a body-centered cubic lattice, a_{γ_1}, at some 0.035 kX below a_γ. Finally, a third series of lines, also of a body-centered cubic lattice and termed a_{γ_2}, appears at 3.350 kX after heating at 550°C. Sample 4

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Decomposition of the ...

has unchanged parameters throughout. The significant temperature ranges of samples 2, 3 and 4 were reaxamined by submitting these samples to isothermal heating for different periods and testing the products for hardness and by x-ray analyses. Thus, sample 2 was heated to 285°C for up to 760 hrs, and to 500°C for 50 hrs; sample 3 - to 480°C for 50 hrs and also to 550°; and samples 4 and 5 to 550°C. The following conclusions were reached: Decomposition of the γ-solid solution is primarily a function of the Nb contents; it proceeds homogeneously at below 30 at.% of Nb and heterogeneously at 30 at.% and above. At the limit of 30 at.%, the decomposition mechanism depends on the temperature of isothermal tempering: It is homogeneous up to 450°C and heterogeneous above 450°C. The heterogeneous decomposition of samples containing 40 at.% proceeds in two stages: (1) The separation of α-U in the first stages gives rise to the formation of the metastable γ_1-phase; (2) γ_1 is transformed into γ_2, the latter being probably supersaturated with U and in equilibrium with γ_{Nb} (containing 72 at.% of Nb). The effect of age-

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Decomposition of the ...

ing (rise of hardness with heating time) is a function of the quantity of separated-out uranium and, therefore, decreases as more Nb enters the alloy. The temperature, at which the decomposition begins to proceed at an appreciable rate, rises along with the rise in Nb content of the alloy and so does the temperature corresponding to a hardness maximum. Finally, the parameters of both metastable phases decrease as the Nb content increases. There are 10 figures and 1 Soviet-bloc reference.

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AUTHORS: Ivanov, O. S., Badayeva, T. A., Semenchenkov, A. T. and Kuznetsova, R. I.

TITLE: The structure of the system uranium-molybdenum at 600 - 1200°C and the properties of its alloys

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 48-67

TEXT: This work was aimed at providing experimental data for the construction of an equilibrium diagram for the above system, in the temperature region of 0 - 800°C and for the composition range of 0 - 32 at.-% molybdenum. Firstly, the region of occurrence of the ß-phase was explored by studying the transformations, occurring in alloys containing 0.5 - 5 at.-% Mo. The samples were cut from alloys cast in a high-frequency furnace, homogenized for 48 hours, at 800°C and then successively held at 600°C (12 hrs), 500°C (240 hrs), and 400°C (240 hrs). Dilatometric investigation at up to

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The structure of the ...

800°C showed that, at less than 4 at -% Mo, there is a gap between the end of the $\alpha \rightarrow \beta$ transformation and the beginning of $\beta \rightarrow \gamma$; this gap disappeared at higher Mo contents. On the other hand, micrographs of samples (quenched from 675 - 750°C and heated before for long periods) show the existence of a γ-phase in samples containing only 1 at.-% Mo; this phase goes up to 80% of the total volume, at 5 at.-%. On the strength of this evidence, the $\beta/(\beta + \gamma)$ boundary is markedly displaced towards the Mo-poor side. The second series included samples containing 0.05 - 90 at.-% Mo. Micrographs recorded on cast samples in the range of 24-90 at.-% confirmed the peritectic nature of the crystallization. Dendritic liquation was observed in the range of 24 - 36 at -% and led to the assumption of a peritectic point at 32- 36 at.-% Mo. The microstructure of homogenized (1000°C for 72 hrs) and quenched samples consisted of 2 phases, beginning with a content of 35.2 at.-%. A 90 at.-% alloy contained only 8 - 8% (per volume) of the γ-solid solution, indicating the limited solubility of uranium in molybdenum. Small nuclei of the second phase were clearly seen within the γ_{Mo}

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The structure of the ...

solid solutions. The hardness-composition curve showed a maximum at 3.5 at.-%, indicating the $\alpha \rightarrow \gamma$ transformation; a minimum at 11 at.-%, corresponding to the transformation $(\alpha + \gamma) \rightarrow \gamma$; and a broad maximum at 38 at.-%, indicating $\gamma \rightarrow (\gamma + \gamma_{Mo})$. The hardness ranged from 120 to 425 kg/mm^2. The curve of the lattice parameter vs. composition for the γ-solid solution is and almost straight line leading from 3.467 kX to 3.140 kX; according to this curve, the $\gamma/(\gamma + \gamma_{Mo})$ boundary at 1000°C was set near 35.5 at.-% Mo. The X-ray analysis of Mo-poor samples showed that within the range of 0 to 8 at.-%, b fell from 5.852 to 5,784 kX, while a and c did not change and the atomic volume decreased, from 20.64 to appr. 20.3 (kX)^3. A separate X-ray series of tests in the range of 0.63 - 5.06 at.-% was performed on samples quenched from 800°C. A mixture of α- and ß-phases was identified at up to 2.27 at.-%; at 2.93 - 5.06 at.-%, only α was present. Similarly, X-ray analyses were performed on samples quenched from 750°, 700°C and 600°C, following prolonged heating periods. At the latter temperature both hardness and micrography analyses indicated the $(\alpha + \gamma)/\gamma$ boundary to be at 17.5

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The structure of the ...

at.-% Mo. There are 15 figures and 5 references: 1 Soviet-bloc and 4 non-Soviet-bloc. The 4 most recent ferences to the English-language publications read as follows: P. Pfeil, The Constitution of Uranium-Molybdenum Alloys. J. Inst. Metals, 77, 553-570 (Auf.1950); C. W. Tucker, Discussion on the Constitution of Uranium-Molybdenum Alloys. J. Inst. Metals, 78, 760 (1951); P.C.Z. Pfeil and J. D. Browne, Superlattice Formation in Uranium-Molybdenum Alloys, AERE M/R 1333 (1954); E. K. Halteman, The Crystal Structure of U_2Mo. Acta Cryst. 10, 166, (1957).

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33884

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21.2100

AUTHORS: Ivanov, O. S., Semenchenkov, A. T. and Kozlova, N. I.

TITLE: The structure of the system uranium-molybdenum below 600°C and the complete equilibrium diagram of this system

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 68-86

TEXT: The authors investigated the formation of the δ_2-phase below 600°C and its coexistence with other phases in the U-Mo system. The data gathered in this investigation were combined with the authors' and coworkers earlier results (Ref. 1: This publication, p. 48) in order to yield a complete equilibrium diagram, whose uranium rich corner is shown in a figure. Molybdenum depresses the transformation $\alpha \rightleftarrows \beta$ and $\beta \rightleftarrows \gamma$ to such an extent that an eutectic equilibrium, β(~1.4 at.-% Mo) $\rightleftarrows$ ($<$0.1 at.-% Mo) + γ(8 at.-% Mo) is formed near 648°C. The phase ($\alpha + \gamma$) existing below 648°C, meets the $\gamma + \delta_2$

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The structure of the system ...

(U_2Mo)-phase and as a result, a second eutectic equilibrium γ(21.5 at.-% Mo) $\rightleftarrows$ (< 0.1 at.-% Mo) + δ_2 is formed at 572°C. Lastly, the equilibrium $\gamma + \gamma_{Mo}$ meets the equilibrium $\gamma + \delta_2$ and forms a third invariant equilibrium, namely γ(35 at.-% Mo) $\rightleftarrows \gamma_{Mo}$ (~98 at.-% Mo) + δ_2 at 600°C. The boundaries of the δ_2-phase are not fully specified. The γ-solid solution containing 3 at.-% Mo is fully converted on quenching into α' which consists of a supersaturated solution of Mo in α-U. The hardness of α' is sharply increased by a rise in the Mo-content and attains a maximum at 3 - 4 at.-% Mo (400 kg/mm^2 for samples quenched from 1000°C). A further rise of the Mo content causes the hardness to be steeply decreased, thus indicating a depression of the α'-phase. A minimum (100 - 300 kg/mm^2) is reached at 10 - 12 at.-% Mo. At this composition, the cubical lattice of the γ-solid solution is transformed into a tetragonal one, with dimensions a = 3.463 kX, c = 3.372 kX and c/a = 0.9737 at 10 at.-% Mo. The tetragonal nature of the lattice is less pronounced at 12 at.-%

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The structure of the system ...

(c/a = 0.9847) and vanishes completely at 13 at.-%. The hardness of γ-solid solution containing samples rises sharply within the limits of 12 - 16 at.-%; this is followed by an inflection and a subsequent broad maximum. This is interpreted as indicating the transformation of the cubical lattice into a tetragonal. The steep rise of the hardness continues up to the boundary of the two-phase composition ($\gamma + \gamma_{Mo}$); thereafter, the hardness is almost independent of the Mo-content. The annealing of a sample subsequent to its quenching, is characterized by a noticeable increase in hardness, due to the decomposition of α'-phase and of γ-solid solution. On annealing to 250 - 300°C, the tetragonal structure becomes more pronounced at 10 - 12 and at 13 - 14 at.-% Mo, while at 1 at.-% it approaches the dimensions of the δ_2-phase. On subsequent annealing to 350 - 400°C, the X-ray pattern becomes very diffused. On further annealing to 450°C, weak diffused lines of α-U and of the δ_2-phase are formed. These lines gain in strength and clarity, on further annealing the samples to 500° and 550°C. To this corresponds a decrease in hardness. The Mo-rich γ-solid solutions in the range of

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The structure of the system ...

500°C are decomposed as a result of both α-phase separation and the formation of the δ_2-phase. The former process is the leading one, in the composition range of 20 at.-% Mo. This separation and the inherent heterogenization is accompanied by a rise in hardness; while the formation of the δ_2-phase, at 30 at.-%, leads to a small decrease of hardness. There are 15 figures and 3 references: 2 Soviet-bloc and 1 non-Soviet-bloc. The reference to the English-language publication reads as follows: E. K. Halteman, The crystal structure of U_2Mo. Acta Cryst. 10, 166 (1957).

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18.1247
21.2100

AUTHORS: Ivanov, O. S. and Vingil'yev, Yu. S.

TITLE: Transformation of the γ-solid solution in double alloys of uranium and molybdenum

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 87-92

TEXT: The authors investigated the kinetics of transformations occurring in the γ-solid solution of quenchend U-Mo alloys. Samples containing 20, 30, and 40 at.-% Mo were quenched from 1000°C and subsequently held at gradually rising temperatures, for periods of 50 hrs. Every individual heat-up was followed by hardness and X-ray analyses. The compositions chosen were situated to the left of, within, and to the right of the region of existence of the δ_2-phase, in that order (Ref. 1: O. S. Ivanov and coworkers: This publication, p. 68). The following results were obtained: Sample 1 (20

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Transformation of the ...

at.-%): The hardness rose slowly up to 400°C, quickly to 520 kg/mm^2 at 450°C and fell smoothly down to 300 kg/mm^2 at 600°C. Its lattice dimension, a, remained unchanged at ~3.41 kX up to 400°C and fell slightly to ~3.36 kX at 575°C; at the same time, the X-ray pattern showed only weak and diffused lines of δ_2 besides those of α-U. The minimum at 575°C corresponds to the reversible transformation, $\delta_2 + \alpha \rightleftarrows \gamma$. The hardness curve of sample 2 (40 at.-%) was unchanged up to 400°C; it then fell abruptly to 370 kg/mm^2 at 450°C, proceeded horizontally up to 600°C and there rose sharply to exactly its initial value, 425 kg/mm^2. The a-parameter curve proceeded horizontally up to 450°C, rose to a smooth maximum of 3.39 kX at 550°C and fell back to its original value at 600°C. The more elevated temperature of the $\gamma \rightarrow \delta_2$ change was due to the higher Mo content.

Sample 3 (30 at.-%) showed a very small decrease in hardness, up to 410°C, while aγ = 3.375 kX was left unchanged. At 435°C, only aγ changed by rising to 3.385 kX and a tetragonal structure began to appear. On raising the temperature to 500°C, the hardness fell by

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Transformation of the ...

20 kg/mm^2 and the a/c ratio continued to increase. The continuous character of the transformation $a_\gamma \rightarrow a_{\delta_2}$ was demonstrated by the unbroken parameter curve; a_{δ_2} reached a maximum of 3.426 kX at 550°C, while c/a and c_{δ_2} passed through a shallow minimum; on heating to higher temperatures c/a tends to unity and, at 615°C, a is back to 3.376 kX, while the corresponding hardness is also almost identical with the initial one. Kinetics of the $\gamma \rightarrow \delta_2$ transformation were investigated by isothermally annealing sample 3 at 500°C and plotting the change in hardness, a, and c/a against time. The hardness rose slightly after 90 min and then fell smoothly from 375 to 330 kg/mm^2 over the next 8-10,000 min; a_γ began to rise after ~70 min from 3.375 kX to ~3.42 kX over 50 hrs; c/a changed from 0.975 (after 300 min) to 0.960 (after 50 hrs). The following transformation mechanism is proposed: Small regions of δ_2 phase

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Transformation of the ...

with a considerable degree of order are formed within the γ-solid solution; both phases are coherently bound together by their (001) planes. The proportion of δ_2 phase increases with the temperature (or the period) of the heat-up and the transformation is practically complete after 50 hrs at 500°C. There are 3 figures and 2 references: 1 Soviet-bloc and 1 non-Soviet-bloc. The reference to the English-language publication reads as follows: E. K. Halteman, The Crystal Structure of U_2Mo. Acta Cryst., 10, 166, (1957).

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33886

S/640/61/000/000/007/035
D258/D302

21.2100

AUTHORS: Ivanov, O. S. and Gomozov, L. I.

TITLE: The equilibrium diagram of the system uranium-zirconium-niobium; radial sections of the system

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 93-106

TEXT: The present work was aimed chiefly at determining the regions, in which γ-solid solutions may occur and at studying the stability of these solutions after being heat-treated up to 500°C. The investigation was based on the equilibrium diagrams of U-Zr and U-Nb presented by O. S. Ivanov (Refs. 5, 6: This publication, pp. 5, 20) and on that of Zr-Nb given by Rogers and Atkins (Ref. 7: Zirconium Columbium Diagram. J. Metals, 7, 9, 1034-1041 (Sept. 1955)). Specifically, alloys with a fixed atomic weight ratio of Zr to Nb, of 3:1, 1:1 and 1:3 were investigated with the aid of hardness tests, micrographs, and X-rays. The uranium-rich alloys

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The equilibrium diagram ...

were melted in an induction furnace at 10^{-2} torr, while alloys with 35 at.-% and more of combined (Zr + Nb) were prepared in an arc furnace, in an atmosphere of purified organ. The products were homogenized for 48 hrs at 1250°C or for 72 hrs at 1025°C depending on their U-content. They were then forged at 1000 - 700°C into 6 - 7 mm thick rods, in order to determine their technological properties. The isothermal heat-treatment of previously furnace-cooled samples was applied for 1500 hrs at 500°C; 800 hrs at 550°C; 500 hrs at 600°C; 300 hrs at 650°C; 200 hrs at 700°C; 100 hrs at 800°C; 75 hrs at 900°C; and 50 hrs at 1000°C. The 1:1 Zr:Nb radial section was found to be representative of all the others and was, therefore, investigated in detail. Its polythermal diagram is given. At 630°C the 0.5% - 0.5% alloy has the structure of α-uranium; alloys containing up to 7 at.-% of additions possess a gradually diminishing martensitic structure; the latter ceases to exist at 8 at.-% of additions; this composition also shows the highest hardness. At subsequently higher percentages, the γ-solid solution becomes increasingly fixed and vanishes at 20 at.-% An anomalous hardness maximum

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The equilibrium diagram ...

was observed at 35 at.-%. When heated at 530°C for 800 hrs the γ-solid solution starts to decompose at 55 at.-%; only one phase was observed at 60-80 at.-%; and a decomposition sets in at 90 at.-%. That was confirmed by X-ray patterns, which showed α- and γ-lines at up to 55 at.-%; γ-lines only within 60 - 70 at.-%; and both γ and α_{Zr} lines at 80 and 90 at.-% of additions. The $(\alpha+\gamma)/\gamma$ boundary was determined by annealing at gradually increasing temperatures, from 530 to 650°C. Adjoining to the lower side of this boundary, a metastable γ-region was found; the latter phase did not decompose even after heating for 1500 hrs. Alloys poor in uranium had to be heated first at 500°C (1500 hrs) in order to decompose the $(\alpha_{Zr}+\gamma)$ phase. X-ray analyses discovered non-equlibrium γ-lines at up to 92.5 at.-%; γ and γ_{NB}-lines at 95 at.-%; and γ_{Nb}-lines at 100 at.-% of additions. The phase diagram of the 3:1 radial section (3 at.-% Zr : 1 at.-% Nb) differs from the simple U-Zr diagram by the expansion of the γ-phase into the region of lower temperatures. The diagram is almost analogous to that of the 1:1 section. The 7.5% - 2.5% alloy presses a maximum hardness.

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The equilibrium diagram ...

The phase diagram of the 1:3 radial section shows a peculiarly broad stability region of the metastable γ-phase at below 590°C, which was confirmed by X-ray analysis of samples annealed for 1500 hrs at 500°C. Conclusions: The polythermal diagram of the triple system shows, along all the radial sections investigated, an expansion of the γ-phase into the low-temperature region, when compared with the respective double systems. There are 12 figures and 10 references: 8 Soviet-bloc and 2 non-Soviet-bloc. The references to the English-language publications read as follows: H. H. Chiswick et al. Advances in the physical metallurgy of Uranium and its Alloys. Doklad no. 713, predstavlenny na Vtoruyu mezhdunarodnuyu konferentsiyu po mirnomu ispol'zovaniyu atomnoy energii. Geneva 1958 (Paper no. 713, presented on the Second International Cpnference for the Peaceful Uses of Atomic Energy); B. Rogers and D. Atkins, Zirconium Columbium Diagram, j. Metals, 7,9, 1034-1041, Sept. 1955.

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33887

S/640/61/000/000/008/035
D258/D302

21.2100

AUTHORS: Ivanov, O. S. and Gomozov, L. I.

TITLE: The uranium-zirconium-niobium equilibrium diagram: Sections with a constant uranium content and a polythermal diagram of the system

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 107-127

TEXT: The authors aimed at completing the U-Zr-Nb equilibrium diagram. Previous work of the authors (Ref. 1: This publication, p.93) on the uranium based radial section failed to detect the separation of γ-solid solution into layers of $(\gamma + \gamma_{Zr})$ and $(\gamma + \gamma_{Nb})$. To achieve this, the authors prepared melts of constant U-content. The first section with 35 at.-% (Nb + Zr) passed through the critical separation point of the U-Zr system; the second section, with 50 at.-% (Nb + Zr) passed through the corresponding point of the

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The uranium-zirconium-niobium ...

U-Nb system; the third section with 70 at.-% (Nb + Zr) passed through the δ_1 phase region of the U-Zr system. The composition, preparation and analysis of the individual alloys were described earlier. The samples were quenched from 1000°C and held afterwards for 1500 hrs at 500°C, in order to bring them nearer to equilibrium. The polythermal diagram of the first section is characterized by the quick wedging out of the $(\gamma + \gamma_{Zr})$ and $(\gamma + \gamma_{Nb})$ regions, caused by addition of either Zr or Nb and also by lowering the $(\alpha + \gamma)$ surface towards the middle part of the diagram. The slope of $\gamma/(\gamma + \gamma_{Nb})$ was 2 times steeper than that of the $\gamma/(\gamma + \gamma_{Zr})$ boundary, while the slope of the $\gamma/(\alpha + \gamma)$ boundary was less steep. The diagram of the second section exhibited the same peculiarities as the first and showed in addition a metastable γ-phase in the temperature range of 470 - 560°C and within the limits of 25 - 37 at.-% Nb (25 - 13 at.-% Zr). This phase did not decompose even after a heat-treatment of 1500 hrs. The diagram of the third section showed an almost temperature-independent δ_1-phase within the limits

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The uranium-zirconium-niobium ...

of 0 - 2 at.-% Nb. This is followed by a triangular ($\delta_1 + \gamma$) region with the top at 620°C and stretching to within 22 at.-% Nb; a second triangle, of the ($\alpha + \gamma$) region with the top at 440°C is based within 25 and 36 at.-% Nb. The ($\alpha + \gamma$) region is separated from ($\delta_1 + \gamma$) by an intermediate phase ($\alpha + \alpha_{Zr} + \gamma$). The opposite corner of the diagram is occupied by an ($\alpha + \gamma$) region, stretching from 58 to 70 at.-% Nb, and topped at 650°C by a very small region of ($\alpha + \beta + \gamma$), ($\alpha + \gamma + \gamma_{Nb}$), ($\beta + \gamma$), ($\beta + \gamma + \gamma_{Nb}$), and ($\gamma + \gamma_{Nb}$), in that order. The different polythermal sections were projected on a concentration triangle. The resulting projection of the U-Zr-Nb equilibrium diagram is shown in a figure; its description is summarized as follows: (1) A continuous series of solid solutions is formed beyond 1000°C. It is believed that 13 monovariant and 3 non-variant equilibria (the latter at 685°, 645° and 430°) take place in the region below 700°C. (2) The stratification regions of ($\gamma + \gamma_{Zr}$), ($\gamma + \gamma_{Nb}$) and ($\gamma_{Zr} + \gamma_{Nb}$) are wedged out, on adding small amounts of the third component (2,5, 12.5 and 21.5 at.-%

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The uranium-zirconium-niobium ...

respectively); this leads to the formation of a broad region of γ-solid solutions. (3) The initial separation of α-uranium from γ-solid solutions occupies a large part of the diagram's uranium corner; the site of this region diminishes towards the middle of the diagram, along with the decrease in temperature. (4) At temperatures below 600°C, the γ-solid solution borders a metastable γ-phase. (5) The solubility of niobium in the δ_1 phase is not higher than 2 at.-%. (6) The triple system contains only phases with crystal lattices, found in the constituent double systems. No new crystal lattices were detected. There are 16 figures and 3 references: 2 Soviet-bloc and 1 non-Soviet-bloc. The reference to the English-language publication reads as follows: B. Rogers and D. Atkins, Zirconium-Columbium Diagram. J. Metals, 7, 9, 1034-1041 (Sept. 1955).

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21.2100

AUTHORS: Gomozov, L. I. and Ivanov, O. S.

TITLE: Behavior of uranium-zirconium-niobium alloys on quenching and on thermal treatment

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 128-140

TEXT: The authors studied the behavior of U-Zr-Nb alloys in order to establish the course of transformation of the γ-phase occurring as a result of the following treatments: (1) Quenching from 1000°C; (2) quenching from 1000°C, followed by heat-treatment (3 hrs for a time at 400°, 450°, 500° and 550°C, in that order; then 10, 25 and 100 hrs at the latter temperature). X-ray results from the first treatment were supplemented by earlier hardness data, of O. S. Ivanov and coworkers (Refs. 1 to 4: This publication, pp. 93, 107, 5 and 20 respectively). The results obtained from X-ray analyses are presented in the form of equal parameter curves on a triangular

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diagram. The hardness data obtained for the heat-treated alloys are presented in a similar way. The first treatment resulted in the detection of the following phases: α', a supersaturated solid solution based on α-uranium; δ', a solid solution of U, Zr, and Nb, with a tetragonal lattice; γ', the initial three-component solid solution, with a cubical structure; α'_{Zr}, a supersaturated solid solution, based on α-Zr; ω, a metastable, Zr-based phase with a hexagonal lattice; and the intermediates $(\alpha' + \gamma)$, $(\alpha' + \gamma')$, $(\alpha'_{Zr} + \omega)$ amd $(\omega + \gamma)$ (ß). The slope of the region boundaries towards the U-Zr side is interpreted as a somewhat increased depressing effect of combined Zr and Nb on the martensitic transformations. The wedging-out region of the γ'-phase is somewhat displaced towards the Zr corner. The marked displacement of the fixed γ-phase towards the Nb corner, as detected by hardness tests, is probably caused by a martensitic transformation occurring during these tests. The equal-parameter lines of the γ-phase in the triple system at rela-

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33888
S/640/61/000/000/009/035
D258/D302

Behavior of uranium-zirconium-...

tively low U-contents (30-50 at.-%) show a slightly negative deviation from additivity; this is compared with the corresponding positive deviation, observed in the constituent double systems. The results of the second treatment show that the decomposition products of triple alloys containing 5 - 20 at.-% of additions, proceeds at a markedly lower rate of coagulation than the one observed in double alloys. Also, there is almost no change in the hardness of regions adjoining the γ-phase, the latter being stable at 500°C. There are 10 figures and 9 Soviet-bloc references.

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33890

S/640/61/000/000/011/035
D205/D302

21.2100

AUTHORS: Ivanov, O. S. and Bagrov, G. N.

TITLE: Isothermal sections at 600°, 575° and 500°C, polythermal sections and the phase diagram of the triple system uranium-molybdenum-zirconium

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 166-190

TEXT: This is a direct continuation of previously published work (Ref. 1: This publication, 141-165) using the same materials and methods. It is concerned with the properties of the U-Mo-Zr system at lower temperatures. The isothermal sections at 600°, 575° and 500°C are graphically presented along with the changes of hardness and lattice parameter for the sections with 70%, 60%, 50%, 40% and 20% at.-% of U. The polythermal sections of the following constant compositions are graphically presented: a) Zr : Mo = 1 : 3; b) Zr : Mo = 1 : 1; c) 70% U; d) 60% U. A projection of the phase dia-

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D205/D302

Isothermal sections at ...

gram of the triple system U-Mo-Zr on the concentration triangle and the two binary diagrams U-Mo and Zr-Mo are given. A full scheme of the mono- and invariant transformations in the triple systems is presented diagrammatically. The main conclusions which follow pertain also to the preceding paper (Ref. 1:Op. cit.). It is stated that the simultaneous solubility of Mo and Zr in U is greatly limited by the formation of $ZrMo_2$ (ε-phase). Therefore, the γ-phase triple solid solutions exist only in narrow stripes along the binary systems U-Zr and U-Mo. The isothermic sections were revealed to be fairly complex, in particular in the 675 - 575°C range, owing to the presence of intermediate phases and $ZrMo_2$. It was possible to establish the regions of the existence of homogeneous γ-solid solutions. In the 675 - 650°C range a new phase δ_3 is formed, having a peculiar lattice and high hardness. This phase exists down to 550°C. On the basis of 9 isothermal and 4 polythermal sections, the polythermal diagram of the U-Mo-Zr system was constructed for the first time in the region of the solid-state transformations. 31

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Isothermal sections at ...

monovariant, 3-phase equilibria and 11 non-variant, 4-phase equilibria were revealed. The most important element of the diagram is the surface limiting the γ-solid solution region from the high Mo and Zr concentration side. The constructed diagram, together with the transformation scheme, are very important for determining the characteristics of the alloys in the system. The volume-centered cubic solid solution U-rich (γ) or Zr-rich (γ_{Zr}), changes the lattice on quenching, in the first case to a lattice of α-uranium, in the second case to that of α-zirconium. In samples containing more of the alloying element, another phase, (ω), having a hexagonal lattice is formed. Annealing over 100 and 1000 hours of alloys quenched from 1000°C has shown that the γ-phase cannot exist after hardening and prolonged maintenance at 500°C. As a result of the decomposition of the γ-phase a special state arises, either a one-phase (δ_4) state or a mixture of four phases. There are 15 figures and 3 references: 2 Soviet-bloc and 1 non-Soviet-bloc. The reference to the English-language publication reads as follows: R. Domogala, D.J. McPherson and M. Hansen, J. Metals, 5,1, 73-79 (1953).

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33891
S/640/61/000/000/012/035
D205/D302

21.2100

AUTHORS: Ivanov, O. S. and Bagrov, G. N.

TITLE: Behavior of γ-solid solutions of the system uranium-molybdenum-zirconium during hardening and annealing

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyenie splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 191-198

TEXT: The question of the γ-solid solution stability at relatively low temperatures is one of the important problems in studying the alloys in the U-Mo-Zr system. If the γ-solid solution decomposes, exposure of alloys having a high hardness is equally important. The investigated alloys are shown in a figure as well as the lines of equal hardness of the alloys, hardened from 1000°C, showing the simultaneous or separate influence of the alloying elements on the hardness. Curves of the hardness change are given for the alloys quenched from 1000°C, and annealed at 500°C for 100 and 1000 hours, for the following sections: Zr : Mo ratio = 1 : 1, 3 : 1, 9 : 1

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Behavior of γ-solid ...

and for sections having constant U at.-% of 90, 70, 50, 40, 30, 20, 10. It is concluded that annealing for 100 and 1000 hours of alloys previously quenched from 1000°C has shown that the γ-solid solution cannot exist for prolonged periods at 500°C in the U-Mo-Zr system. The γ-solid solution decomposes either into a single different phase or into a mixture of 4 phases. After the 1000-hour-annealing, the highest hardness (550 kg/mm^2) was found in alloys having 10 at.-% Mo and 60-30% U. There are 8 figures.

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33892

S/640/61/000/000/013/035
D205/D302

21.2100

AUTHORS: Ivanov, O. S. and Terekhov, G. I.

TITLE: Polythermic sections of the phase diagram unranium-niobium-molybdenum

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyenie splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 199-213

TEXT: The aim of the investigation was to construct phase diagrams of the binary U-Nb system and the ternary U-Nb-Mo system in order to obtain data for the technological production of alloys suitable for reactor service. Special attention was given to the γ-solid solutions. On the basis of previous data, it is assumed that Nb and Mo form a continuous series of solid solutions. The alloys were prepated by smelting in an arc or in high-frequency furnaces, using U - 99.78%, Nb - 99.2% and Mo - 99.9% pure. Thermal treatment under vacuum was used followed by immediate quenching in water. Alloys homogenized at 1100 - 1250°C for 48 - 72 hours were etched for the

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Polythermic sections of ...

investigation of the microstructure and hardness. Phase X-ray analysis was also performed. Polythermic sections with atomic ratios Nb : Mo = 3:1, 1:1, 1:3 were studied and are represented graphically. Conclusions: In the system U-Nb-Mo the two-phase region of two solid solutions based on γ-U and γ-Mo (Nb) - which reaches the solidus line in the system U-Mo - is removed from the solidus surface between the two sections with Nb : Mo ratios 3:1 and 1:1. Thereafter, the bell-shaped surface under which the two-phase region is placed approaches the binary U-Nb system, forming on it a curve of mutual solubility with a maximum at 1000°C and 50 % at. Nb. The surface of limiting simultaneous solubility of Mo and Nb is strongly bent towards the U corner of the diagram, the solubility of these elements in γ-U decreasing sharply moving to the sections Nb : Mo = 1:1 and 1:3. This limits the possibility of obtaining more heat-resisting alloys than the binary U-Mo and U-Nb. Heat-resisting alloys rich in Nb and poor in Mo or vice-versa are the only ones possible. The position of the 3-phase equilibrium $\gamma \rightleftarrows \beta + \gamma_{Nb}$ is explained. There are 11 figures and 7 references: 6 Sc-

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Polythermic sections of ...

viet-bloc and 1 non-Soviet-bloc.

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33893

S/640/61/000/000/014/035
D205/D302

21.2100

AUTHORS: Ivanov, O. S. and Terekhov, G. I.

TITLE: Isothermic sections at 560, 500°C and the phase diagram of the ternary system uranium-niobium-molybdenum

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyenie splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 214-227

TEXT: The nature, structure, and phases of the U-Nb-Mo system in the range 500 - 550°C are of interest because this is the average temperature range of nuclear reactors. The methods and materials employed were described earlier (Ref. 2: This publication, 199-214). It was assumed that at 560 - 570°C a quarternary eutectoidal equilibrium takes place. Alloys with constant U content of 80, 70, 60% and of a part of the Nb : Mo ß 1:15 section were investigated in the 500°C isothermic section, while at 560°C the alloys at constant U content of 90 and 40% were also investigated. The isothermic sections are represented graphically as are also the changes

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33894
S/640/61/000/000/015/035
D205/D302

21.2100

AUTHORS: Ivanov, O. S. and Terekhov, G. I.

TITLE: Isothermic sections for 1200 - 575°C and phase diagrams of the system uranium-niobium-molybdenum

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyenie splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 228-248

TEXT: The data of the polythermic sections previously described by the authors (Ref. 1: This publication, 199-213) are plotted on isothermic sections for 1200°, 1000°, 800° and 700°C. In addition, sections at 600° and 675°C were investigated by the study of alloys having the ratio Nb:Mo = 1:15. All these sections are represented graphically and described. Changes of hardness, lattice parameter and phase transformations are discussed. Conclusions: The equilibrium $\gamma \leftrightarrows (\alpha+\gamma\text{-Nb - Mo})$ recedes into the ternary system from the peritectoidal reaction which takes place at 642°C and spreads out in the system shifting towards the U-Mo side. The γ-solid solution

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Isothermic sections for ...

composition is shifted simultaneously towards the molybdenum corner. With the decrease of temperature in the 600 - 575°C range, a further decrease of the spread of the δ-phase homogeneous region takes place. There are 13 figures and 1 Soviet-bloc reference.

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33895
S/640/61/000/000/016/035
D205/D302

21.2100

AUTHORS: Ivanov, O. S. and Terekhov, G. I.

TITLE: Transformations of the γ-solid solution during quenching and annealing in the systems uranium-niobium and uranium-niobium-molybdenum

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 249-264

TEXT: The systems U-Nb and U-Nb-Mo which have wide regions of γ-solid solutions, present possibilities of martensitic transformations and allow a wide choice of thermal treatments of alloys to achieve their most useful characteristics. The aim of the present work was to follow the decomposition of the quenched state by measuring the hardness after multiple annealings at different temperatures. Stability of the alloys, resistance to softening and coagulation of the dispersed structures were also studied. The changes of hardness of the ternary system alloys of sections

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Transformations of the ...

Nb:Mo = 3:1, 1:1, 1:3, quenched from 1000°C are presented graphically. The same is done for these alloys after annealing for 3 - 100 hours in the 400 - 550°C range. A similar course of investigation was followed for the binary system U-Nb, special attention being given to alloys of 90, 80, 70, 60 and 40 at.-% of U. The annealing at 400 - 550°C of alloys quenched from the γ-region of the binary U-Nb system having up to 30 at.-% Nb causes the decomposition of the α- and γ-solid solutions with a marked change in hardness. From 35% Nb the hard γ-solution was found to be stable after 125 hours at 400 - 550°C. Alloys of the ternary system located at the mentioned sections show, after the annealing treatment, that simultaneous alloying by Nb and Mo gives no improvement in alloying by each of the elements separately. This holds for the preservation of hardness after annealing and for the stability of the γ-solutions as well. Study of the structure of the annealed alloys revealed that the decomposition of the γ-solution in the ternary system is slower than in the corresponding binary U-Nb and U-Mo systems, at equal contents of alloying components. The γ-solution is most stable in the alloys at U content of 80, 70, 60 and 40 at.-% at the Nb:Mo ratio of ~27:73. Annealing for 1100 hours

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Transformations of the ...

brings about the complete decomposition of the γ-solid solution. Judging by the hardness, the most stable in all respects are the alloys having 80-70% U. The slightly alloyed (up to 2 - 3%) U-Nb alloys are of practical interest as they are capable of preserving for prolonged periods, at 400 - 500°C, the finely dispersed quasi-isotropic state. There are 10 figures and 6 references: 5 Soviet-bloc and 1 non-Soviet-bloc. The reference to the English-language publication reads as follows: R. J. Van Thyne and D. J. McPherson, Trans. Amer. Soc. Metals, 49, 576-597 (1957).

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33896
S/640/61/000/000/017/035
D205/D302

21.2100
AUTHORS: Ivanov, O. S. and Virgil'yev, Yu. S.

TITLE: Structure of quadruple alloys of the system uranium-zirconium-niobium-molybdenum at 1000 and 800°C

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyenie splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 265-295

TEXT: Of the high-melting elements suitable for alloying uranium to make it serviceable in reactors, the best with respect to low neutron capture ability are Zr, Nb and Mo. Ti and V are well soluble in γ-U, but have a high neutron capture ability, while Fe and Cr behave in an opposite manner. Other elements of low neutron capture ability are only very sparingly soluble in γ-U and can only serve as minor additives. Therefore, the region close to the U-corner of the above quadruple system is of great interest. 226 alloys lying on the planar sections of the concentration tetrahedron having constant U contents of 80, 70, 60 and 50 at.-% were investi-

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Structure of quadruple ...

binary U-Zr system are limited. The stronger influence of Mo, as compared with Nb on the depression of this transformation is observed in the section with 80% U only; in the other sections the influence of Mo and Nb is equal. There are 33 figures and 11 references: 6 Soviet-bloc and 5 non-Soviet-bloc. The 4 most recent references to the English-language publications read as follows: B. A. Rogers and D. Atkins, J. Metals, 7, 9, 1034 (1955); D. Summers - Smith, J. Inst. Metals, 83, 277-282 (Feb. 1955); R. F. Domogala, D. J. McPherson and M. Hansen, J. Metals, 5, 1, 73-79 (1953); P.C.Z. Pfeil, J. Inst. Metals, 77, 553-570 (1950).

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33897
S/640/61/000/000/018/035
D205/D302

21.2100

AUTHORS: Ivanov, O. S. and Virgil'yev, Yu. S.

TITLE: Investigating the stability of γ-solid solutions fixed by quenching in alloys of U-Zr-Nb-Mo after prolonged annealing in the 430-550°C range

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 296-306

TEXT: The aim of this investigation was to reveal alloys which retain stable γ-solid solutions and are also creep-resisting or, alternatively, alloys which produce hard decomposition products of the γ-solid solutions. The investigated specimens were quenched from the γ-solid solution region at 1000°C and their hardness in the cold state was examined after prolonged annealing (1000 - 2000 hours) in the 430 - 550°C temperature range. The total amount of alloying elements was 20, 30, 40 and 50 at.-%. Curves of equal hardness are shown on the triangular, planar sections of the con-

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Investigating the stability ...

centration tetrahedron. In the alloys of the sections with 80 and 70 at.-% of U the solid solution decomposes entirely during the first 100 hours of annealing at 500°C. Further annealing leads to coagulation of the decomposition structures. In the sections of 60 and 50% U, regions are found in which the decomposition of the solid solution is hampered to such a degree that it remains stable after 1000 hours of annealing. In the more alloyed section of 50% U this stable region persists after annealing at temperatures up to 550°C. With the increase of the sum total of the alloying elements the influence of the decomposition on hardness decreases which is caused by a decrease in the amount of the α-U decomposition product. There are 12 figures and 1 Soviet-bloc reference.

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33899
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21.2100

AUTHORS: Semenchenkov, A. T. and Ivanov, O. S.

TITLE: Structure of alloys of uranium-zirconium-titanium

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 312-324

TEXT: The present investigation presents additional data of the above system, in particular for alloys containing more than 50 at.% of the alloying elements. The alloys were quenched from 900°C, i.e. from the γ-solid solution state. The martensitic transformations and stability of the γ-phase were investigated. The alloys were prepared by smelting in an arc furnace, using U 99.77%, Zr 99.80% and Ti 97.70% pure, under argon. To remove intercrystalline liquation the alloys were homogenized at 1000°C for 72 hours. Forged samples were studied by X-ray powder photography and their hardness was measured. From the limiting binary systems the U-Ti system was investigated more thoroughly. At the Ti concentrations of

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Structure of alloys ...

17.5 - 23 at.-% and 65 - 92%, the γ-solid solution is preserved by quenching, down to room temperature. The alloys of these compositions had hardness ranging from 220 - 300 kg/mm^2. The alloys in the range of 25 - 62.5% Ti contain U_2Ti. Formation of this compound cannot be prevented by the increase of the rate of cooling during hardening. In the U-Zr-Ti system the hardness and lattice parameter changes are plotted for the investigated Zr:Ti = 1:3, 1:1, 3:1 sections. Finally the data obtained are summarized in the phase diagram represented on the concentration triangle and in curves of equal hardness represented in a similar manner. The ternary γ-solid solution, prevailing in the whole system at 900°C is decomposed during quenching. The manner of the decomposition depends on the composition. Very sharp hardness changes occur as a result of these transformations. There are 11 figures and 16 references: 3 Soviet-bloc and 13 non-Soviet-bloc. The 4 most recent references to the English-language publications read as follows: H. A. Saller, F. A. Rough, A. A. Bouer and R. J. Diog, J. Metals, 9, 878, 881, (July 1957); B. W. Bowlett and A. G. Knap-

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Structure of alloys ...

ton, Paper No. 1469, presented at the II International Conference for Peaceful Use of Atomic Energy; E. R. Boyko, Acta Cryst. 10, 712, (1957); M. Mueller, Acta Cryst., 8, 849 (1955).

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33909
S/640/61/000/000/030/035
D205/D302

21,2100
AUTHORS: Ivanov, O. S. and Alekseyeva, Z. M.

TITLE: Investigating the system thorium-uranium monocarbide

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 428-437

TEXT: Owing to the low melting temperature and heat resistance of the Th-U alloys, the introduction of a third element into the system to improve these characteristics was suggested. Carbon, having a low thermal neutron capture cross-section, was first considered. Th forms with C two carbides ThC and ThC_2. At high temperatures Th with ThC forms a continuous series of solid solutions. Uranium forms with carbon a monocarbide having a crystal structure similar to that of Th, namely a face-centered cubic. It could, therefore, be anticipated that Th and UC may form a series of solid solutions between them. the resulting alloys having better characteristics than U-Th alloys. The alloys were prepared from 99.2% Th, 98.95% U

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Investigating the system ...

and 99.9% C, taken as powders, by compression under a 10 t load. The samples were evacuated at 1000°C, annealed and smelted in an arc furnace. After smelting the alloys were examined in cast and quenched states. X-ray, microstructure and microhardness investigations were performed. No alloys representing monophase solid solutions were revealed in the system Th-UC. Because these alloys contain low-melting uranium they are of no special interest as materials for heat-evolving elements of nuclear reactors. It was established that UC and ThC form a continuous series of solid solutions. The study of these materials is interesting as they are potentially useful in heat-evolving elements exploiting Th along with U. There are 5 figures, 1 table and 3 non-Soviet-bloc references. The references to the English-language publications read as follows: F. A. Rough and A. A. Bauer, Constitution of Uranium and Thorium Alloys, Report BMJ-1300, UC-25 Metallurgy and Ceramic (TJD-4500, 13th Ed., rev.) Bat. Mem. Inst., Columbus, Ohio, 1958; M. W. Mallett, A. F. Gerds and H. R. Nelson, J. Electrochem. Soc., 99, 15, 197 (1952); H. A. Wilhelm and P. Chiotti, Trans. Amer. Soc. Metals, 42, 1295 (1950).

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33910
S/640/61/000/000/031/035
D205/D302

21.2100

AUTHORS: Ivanov, O. S. and Alekseyeva, Z. M.

TITLE: Investigating the structure of allcys in the systems UC-ZrC, UC-ThC and ThC-ZrC

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 438-449

TEXT: Investigation of these systems was prompted by the search for high-melting materials, having good heat-transfer properties and good resistance to the corrosive actions of air and molten metals at high temperatures. Zr as an alloying element has the advantage of having a low effective neutron capture cross-section. The alloys were prepared from metallic powders of 98.95% U, 99.2% Th, 99.2% pure Zr, and from graphite powder having less than 0.1% ash, by metalloceramic methods with subsequent smleting in an arc furnace under pure A. X-ray investigations, microstructural analysis and hardness measurements were performed. The linear change

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Investigating the structure ...

of lattice parameter from pure UC towards pure ZrC has shown that a continuous series of solid solutions is formed between the two compounds. The hardness of pure UC (850 kg/mm^2) increases gradually with the increase of Zr content, reaching a maximum of 2130 kg/mm^2 at 45 at.-% Zr before decreasing back to 1920 kg/mm^2 for pure ZrC. The rise in Zr content in the UC-ZrC system increases the resistance to oxidation. Alloys of 5 - 10% U are resistant to air oxidation up to 400°C. The linear change of the lattice parameter from pure UC to pure ThC has shown the existence of a continuous series of solid solutions between these compounds. Samples prepared by sintering, belonging to this system, are easily oxidized by air. The most stable (10 at.-% Th, 40% U and 50% C) is destroyed in air at room temperature after two days. Samples prepared by smelting are more resistant. The system ThC-ZrC reveals the formation of limited solid solutions. The temperature dependent solubility of ZrC in thorium carbides is limited. ThC does not dissolve in ZrC. Chemical stability of the alloys of this system in air is low, increasing with decreasing ThC content. There are 6 figures, 1 table and 4 references: 1 Soviet-bloc and 3 non-Soviet-bloc. The references

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Investigating the structure ...

to the English-language publications read as follows: M. W. Mallett, A. F. Gerds and H. R. Nelson, J. Electrochem.Soc., 99, 5, 197-204 (1952); P. Chiotti, J. Amer. Ceramic Soc., 35, 5, 123, (1952); H. A. Wilhelm and P. Chiotti, Trans. Amer. Soc. Metals, 42, 1295 (1950).

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33911

S/640/61/000/000/032/035
D205/D302

21.2100

AUTHORS: Ivanov, O. S. and Alekseyeva, Z. M.

TITLE: Investigating alloys in the ternary system UC-ThC-ZrC

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyeniye splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 450-456

TEXT: On the basis of the preceding paper by the authors (Ref. 1: This publication, 438-449), which revealed the formation of a continuous series of solid solutions in the UC-ZrC and ThC-UC systems and of limited solid solutions in the ThC-ZrC systems, the existence of ternary solid solutions on the ThC-UC-ZrC system was anticipated. This study, performed in 1957, has subsequently been confirmed by Western work. 24 alloys placed on 3 polythermic sections of UC:ThC = 1:1 (up to 21% of ZrC), UC:ZrC = 1:1 (up to 10% ThC), and ThC:ZrC = 1:1 (along the whole section) were investigated. The alloys were prepared by methods described in Ref. 1 (Op. cit.). The annealed alloys were quenched from 2050°C and investi-

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Investigating alloys in ...

gated by X-rays together with the cast unquenched samples. The isothermic section at 2050°C is presented graphically. The limits of the monophase region at the ternary solid solutions were determined in the temperature range from 2000°C to the melting point. It was established that this region lies along the UC-ThC and UC-ZrC sides of the concentration triangle, cutting the ThC-ZrC side at ~5 and ~50 at.-% Zr. The rest of the concentration triangle is occupied by a two-phase region. There are 4 figures, 1 table and 4 references: 1 Soviet-bloc and 3 non-Soviet-bloc. The reference to the English-language publication reads as follows: L. D. Brownlee, J. Inst. Metals, 87, 2, 58 (1958).

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33889
S/640/61/000/000/010/035
D205/D302

21.2100

AUTHORS: Ivanov, O. S. and Bagrov, G. N.

TITLE: Isothermal sections of the triple system uranium-molybdenum-zirconium at 1000-525°C

SOURCE: Akademiya nauk SSSR. Institut metallurgii. Stroyenie splavov nekotorykh sistem s uranom i toriyem. Moscow, Gosatomizdat, 1961, 467-481

TEXT: Unalloyed uranium is not suitable for use as a reactor fuel because of its low strength above 500°C, change in dimensions and knoll formation at cyclic loads, low corrosion resistance and easy oxidation. Zr and Mo are drawing attention as alloying elements owing to their high solubility in γ-U and their strong influence on the structure and properties of U alloys. The alloys investigated were prepared in argon. For microstructural investigations the alloys were etched. Unfiltered Kα-Fe radiation was used for the X-ray analysis. The hardness was measured by a diamond indentor at 10 kg load on a ТП (TP) apparatus. The alloys were annealed at the

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Isothermal sections of the ...

corresponding temperatures and hardened by quenching in water. Isothermal sections of the phase diagram are given at 1000, 750, 675, 650 and 625°C. Changes of the hardness and lattice parameter are shown graphically for the sections at 70.50 and 25 at.-% U and also for a section having a constant 1 : 1 ratio of Zr : Mo. There are 15 figures and 4 references: 2 Soviet-bloc and 2 non-Soviet-bloc. The references to the English-language publications read as follows: R. F. Domogala, D. J. McPherson and M. Hansen, J. Metals, 5, 1, 73-79 (1953); W. Hume-Rothery, Phil. Magaz., 22, 1013 (VII) (1936).

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IVANOV, O.S., doktor khim.nauk; TSEYTLIN, V.Z., kand.tekhn.nauk; GOMOZOV, L.I., kand.tekhn.nauk; LARIONOV, V.V., inzh.

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